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(1 soft copy to Dr. Ullal; 1 hard copy to Ms. C. Lopez)

Re: Third Monthly Report on Pulsed Light Annealing #NDJ-2-30630-11 Mod 6

Dear Harin,

This letter comprises the third monthly technical status report for “CIGS Film Fabrication by Pulsed Light Annealing of Precursor Films”, which is a task added as Mod 6 to ITN’s subcontract #NDJ-2-30630-11, “Plasma-Assisted Coevaporation of S and Se for Wide Band Gap Chalcopyrite Photovoltaics”, under the Thin Film Partnership Program. This letter describes work performed during the reporting period of November 15, 2003 through December 14, 2003.

Goals and Approach

The primary objective of this research effort is to demonstrate the production of high-efficiency thin-film CIGS solar cells on polyimide substrates by using high-rate heating from a super-intense pulsed light source. The heating rates to be investigated (millisecond time-scale) are at least two orders of magnitude higher than those reported in previous efforts to use Rapid Thermal Processing (RTP) to convert precursor materials to CIGS films for photovoltaics. Higher heating rates may be advantageous in that (1) thermal degradation of the substrate may be avoided with fast annealing and, (2) diffusion of gallium to the back of the film, which is a major limitation encountered in other CIGS RTP work, may be dramatically reduced. Goals of the present investigation are to determine the viability and challenges of using short (<50 ms) pulses from a super intense light source to:

- Convert sputter-deposited precursor films to chalcopyrite-phase CIGS.
- Improve co-evaporated CIGS electrical properties and thereby allow the use of lower deposition temperatures while retaining device performance.
- Develop a method for CIGS film production that is well suited for production scale-up and capable of producing efficiencies that match those achieved using high-temperature co-evaporation.

An additional goal will be to determine whether high-rate heating can effectively eliminate thru-film and lateral diffusion of elements during conversion of precursor structures to produce CIGS films with high front-side gallium content.

Activities

During the third reporting period for the Pulsed Light Annealing task, activities consisted mainly of preparation for depositing precursor layer films and design of the sample holders that will be used during pulsed light annealing.

Preparation for sputter deposition of precursor layer films was consisted of determining a power-versus-rate calibration factor and quantifying the degree of uniformity across the substrate area. Uniformity was expected to be good due to the use of a substrate holder with single-axis rotation. Unfortunately, it was found that not only was uniformity not as good as expected, but there was a significant difference between the film thicknesses at different corners of the substrate that were at the same radial distance from the axis of rotation. An effort to track down the source of corner-to-corner variations found that the plane of substrate holder was not perpendicular to the axis of rotation. Correcting this appeared to reduce, but not eliminate, the corner-to-corner variability (see Figure 1). One possibility for the remaining variability may be poor reproducibility in the XRF thickness measurement. To check this possibility, another run was performed with glass substrates so that film thicknesses could be measured using a Dektak profilometer. The Dektak measurements also showed a large spread indicating either poor reproducibility in both Dektak and XRF thickness measurements or actual corner-to-corner variability in sample thickness.

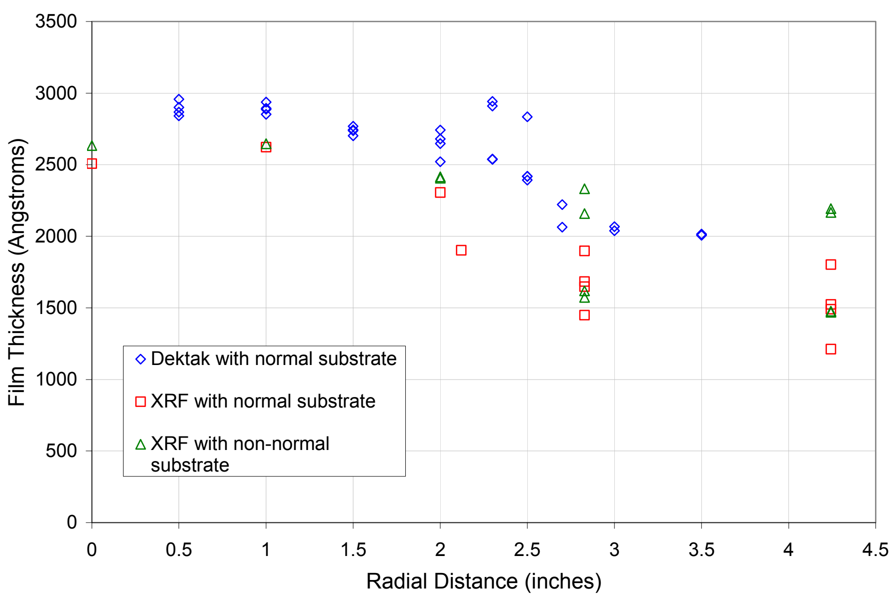

Figure 1: Copper film thicknesses measured by XRF and Dektak at various points on the substrate as a function of distance from the axis of rotation.

Concept definition has been completed for two sample holder designs. As reported previously, one sample holder design will hold the sample in a freestanding configuration while the second backs the sample against a larger thermal mass. Both designs include measures to minimize the risk of selenium contaminating the flash-lamp system while allowing purge gas to flow through the sample region. Manufacturing drawings were completed for one design and feedback from the head of the flashlamp facility indicates that only very minor revisions are required. We are currently targeting to have both sample holder designs fabricated and a set of precursor film samples ready in time for conducting the first set of flashlamp annealing experiments in early February.

Best Wishes,

Garth Jensen
Co-Principal Investigator
ITN Energy Systems

Cc: Ms. Carolyn Lopez; NREL contracts and business services